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ABSTRACT

This document, published in India by the Regional College of Education, deals with 13 subjects: the tough context (thinking), definitions of concept, functions of concept, the process of concept formation, discriminant learning, mediation process, second signalling system, factors affecting concept formation, studies in concept formation, the Geneva school, two illustrations, acceleration in concept development, and information processing and decision making. It includes two appendices: (1) characteristics of abstract as compared with concrete thought, and (2) the problematic territory of Jean Piaget and adolescent thought. In addition, there is a bibliography and a preface on Jean Piaget on Education. (SK)

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CONCEPT FORMATION

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JEAN PIAGET ON EDUCATION

Why is there no Piagetian dogma about education? To begin with it is almost impossible to pin down any educational method and say that it is 'the' or even 'a' Piagetian method. The actual psychological significance of any method changes in suitable ways depending on the teachers understanding of children's thinking. Piaget has devoted his efforts to changing our understanding of the child, for some this is only a prelude to the development of new educational means, for others it is the new means.

Moreover, it is alomst impossible to separate means from ends in applying Piaget's ideas to education. Activity is the means by which growth of the cognitive structures comes about, and activity is the functioning of those structures. Activity nourishes the structures that guide the activity. Thus we cannot say simply that activity is the means and cultivation of the structures the end. They are inherently inseparable and, least at this stage, that make ordinary discussion difficult.

Finally, Piaget's contributions fall in three main areas, which leave it up to educators looking for guidance to draw upon them in varying proportions:

1. He emphasizes the importance of activity in the growth of intelligence.
2. He explores in depth the growth of the child's thinking in relation to certain universals in the contents of human experience such as the nature of objects, space, time, motion, chance, causality, moral responsibility, and social awareness.

3. He proposes that certain underlying pervasive logic mathematical structures are found repeatedly in these diverse areas. Taos, Paris (Pleasure of discussion) Athens (the Socratic method) and Eldorado are the four models worthy of consideration while schematizing the materials and exercises on the one hand, and the type of social relationship on the other.

We have said enough to support the statement that there is no Piagetian educational dogma. We can go further now: If there were Piagetian educational dogma it would be necessary to destroy it. Regardless of their many virtues, professional innovators know so much that they often have the effect of intimidating the people they are trying to help. This effect is especially harmful in education. We do not need intimidated teachers, even if they are coerced into doing the right thing. For the teachers all dogma is bad, even good dogma. Probably the best thing that each group of teachers can do is to invent the approach that fits their situation. Piaget's remarks that only by reinventing a theory can a child understand it, applies equally well to all adults. If the teacher is to understand what he is doing, he must invent it; he can neither invent it well nor understand it if he does not understand the child. What Piaget has done can only be an aid to that understanding, without which teachers cannot invent and reinvent their practice.

Howard E. Gruber, & J. Jacques Voneche
In
The Essential Piaget

FOREWORD

The study of concept formation has received the attention of educationists and psychologists for quite a long time. Earlier, the philosophers had their views about concept-formation, but empirical studies became possible much later only with the emergence of psychology as a science. Since then, there has been a large number of studies. It is difficult to encompass all these studies in a single volume. Any research worker has to search vast literature in this field in order to do any significant piece of work in this area Hence, there have been in the past several attempts to bring together in one volume the findings of research spread over 100 years or more. The present volume shows another attempt to present the various theories, methods and findings in this field.

In teaching, one of the primary tasks of the teacher is to help the pupil in developing concepts. In this task the teacher follows certain principles of teaching recommended by educationists. The usual idea is to develop slowly through specific experiences some notions and symbols, in the form of categories, encompassing the specific experiences encountered by the child. The progress is from the concrete to the

abstract. There is also the other view that it is better to start with the abstract or rule and gradually concretise it through specific experiences, illustrations etc. Any classroom teacher, however, makes a compromise between these two approaches and shifts from the inductive to the deductive approach as and when required, depending on the teacher's judgment of the abilities of children under his care and the knowledge which they have already acquired. It also depends on the subject matter itself. In the teaching of mathematics for example, one tends to take the deductive approach as against that of history. In the teaching of languages, one tends to follow the rules of grammar and make the children earn the rules through various illustrations. It is, therefore quite appropriate for Professor Vaidya to have attempted to place in this book the theories and methods of concept formation. This should help the teacher to understand his task a little better.

In recent times, the work of Piaget has received a lot of attention, although his work was actually done about half a century ago. Piaget's work has influenced a lot of thinking and further research in the area of pedagogy, curriculum construction as well as the psychology of concept-formation. It is worthwhile for any serious student of education to be acquainted with the work of Piaget in this regard and this book offers him that opportunity.

I hope that the book will be found useful by educationists.

National Council of Educational
Research and Training,
New Delhi—110 016
12th March, 1980

Shib K Mitra
Director

PREFACE

A change of field has its own hazards, frequently very hard to cope with. Having switched voluntarily from Physics via education to psychology and that also having epistemological flavour, I had my first love with Concept Formation in 1958-59 at the Central Institute of Education, Delhi University, Delhi under the guidance of Dr. (Mrs.) Krishna Swamy, Director Central Bureau of Text Books Research, Ministry of Education, Government of India, I failed but continued the endeavour at the Institute of Education, University of London in the years 1961-64 under direction of Dr. (Mrs.) D. M. Penfold, Senior Lecturer in Statistics. Result ! The problem was dropped for the next fourteen years or so until academic as well as financial support became available from the Educational Research Innovation Committee of the N. C. E. R. T. New Delhi under the chairmanship of Prof. S. K. Mitra and Prof. R. C. Das respectively for added clarity in the problematic field through the medium of schemes of thought in science during adolescence. The gravity of my puzzlement could be appreciated if one goes through the following remarks of Prof. Barbel Inhelder, a life long co-worker of Prof. Jean Piaget now epitomized as the Geneva School in 1976 :

> Pleasing though this extension is, however, we are somewhat disturbed by the fact that the replication of our experiments does not always show a sufficient understanding of Piagetian theory on the part of the authors of these new works. We are of course the first to admit that such understanding is not easy to acquire especially since this form of psychology is closely linked to a certain form of epistemology. Once understood, this form of epistemology appears to be that

which best suits genetic psychology as both are essentially constructivist. Constructivism implies that knowledge is not acquired merely under the impact of empirical experience, as suggested by behaviourist theory, although of course, such impact is not entirely excluded from the process It is also opposed to innate theory, to which, it seems, recourse is frequently had today (maturation being a factor which intervenes, but not exclusively). Constructivism emphasizes the child's or the subject's activity during the course of cognitive development : in other words, everything derives from actions and is eventually translated into coherent and logical thought operations.

At the current moment, Piaget is splitting "as" well as coalescing in several branches of knowledge. His long awaited fifth stage comprising aptitude variation, specialization and critical reflection is coming up clearly and awaits to be empirically tested Having said this, the present document on concept formation presents and consolidates research efforts in this area from several standpoints for the benefit of the researcher with a view to formulate issues more and more productively in the phraseology of Gestalt Psychology, for deeper and deeper waters are yet to be traversed in this area. If this is not done, it will be awfully difficult to talk on Concept Formation firmly for the benefit of classroom teachers. In the absence of this theoretical knowledge, as well as if theory in education is ever to guide practice in the present century of Science, Engineering and Technology, most of the efforts for the concept development at school are bound to fail. Also, the various school subjects will have no chance for developing their own individual psychological structures. I am

aware of the weaknesses in this document. For example, the works of Gagne and Ausuble do not find any mention but both of them equally offer rich ideas to teachers but they are yet to be talked of in a big way in this country. They are, however, being taken care of in another lengthy document on "Analysis of Studies on Formal Thought" which is nearing completion. This piece of investigation is a little effort in that direction for it hardly prescribes in the area of educational practice.

I owe a sense of gratitude to many. Particularly speaking I am highly obliged to the following :

Prof. R. P. Singh, N. C. E. R. T., New Delhi, Prof. J. K. Bhatnagar, Concordia University, Montreal, Canada, Dr. Amarjeet Singh, School of Education, Reading University, Reading, England, Dr. J K. Sood, Dr. G. N. Bhardwaj and Shri S. C Jain, Regional College of Education, Ajmer.

Last but not the least, I am also thankful to Mr. T. S. Sandhu and Miss Padmini M. S. who in fact helped me a lot in the physical preparation of this manuscript.

Ajmer
Feb., 1980

Narendera Vaidya

The more we learn (about the nature of man) the more will it contribute to our wonder; the more competent we become, the more humble and respectful.....the more we try to discover man, the more we will discover men..... ... when we gradually discover that we are united with all things, we may learn our closeness with one another; when we find out all there is to know about how we came out to be as we are, we will value above all that which we are not yet; when we begin to value this, we will have prepared for the openness that alone could bring a new world in being.

Becher Ernest
in
Alienations

'Use of a human being in which less is demanded of him than his full stature is a degradation and a waste. It is degradation to a human being to chain him to an oar and use him as a source of power, but it is an almost equal degradation to assign him to a purely repetitive job in a factory, which demands less than a millionth of his brain capacity. It is simpler to organize a factory or a galley which uses human beings for a trivial fraction of their worth than it is to provide a world in which they can grow to their full stature.

Norbert Weiner
in
The Human Use of Human Beings

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Verily, it is easier for a camel to pass through the eye of a needle than for a scientific man to pass through a door.

A. S. Eddington

CONCEPT FORMATION

The Tough Context : Thinking

Thinking as it goes on in our heads is not a physical process for it is inferred rather than observed (21, 92). In literature, it has been variously described as 'abstracting, analysing, categorizing, deducing, defining, discriminating, estimating, generalizing, guessing, imagining, judging, knowing, opining, reasoning, recalling, recognizing, reflecting, remembering, searching for conclusions and understanding' (81, 95, 98). While going ahead, one has first to cross the territory of concept formation, a vast area of investigation in its own right, having strong links, but not identical with, such complex psychological processes as thinking, learning, problem solving, language acquisition and symbolic representation. If this journey is further continued, concepts enter the complex areas of problem solving, creativity, critical thinking, originality and even personality (98). Difficulties for the cognitive psychologists go on increasing for the layman, practitioners and the general psychologists do not invariably ask the same questions. As if, the problems already stated were not sufficient, the territory of concept formation, unlike the areas of sensation, perception, learning and motivation, lacks both methodological as well as conceptual unity (48). So it looks forward to the borrowings from other areas in ascertaining facts about its own domain. For achieving success here, problems have to be posed more and more productively in the phrasseology of Gestalt psychology with a view to investigate the complex processes of thinking which, in turn, may ultimately lead to the development of understanding, generalization, discrimination and concept development, with experimental intervention, of course, not excluded. When all such issues are considered

together, the basic problem remains to relate the most significant concepts of our physical as well as social environment to the mental development of children, whose answer goes a long way in providing the psychological structure to any one of the school subjects.

Thanks to the recent efforts of Ausubel, Bartlett, Beard, Bruner, Flavell, Gagne, Guilford, Hansfurth, Hearnshaw, Inhelder, Kraplus, Lovell, Lunzer, Peel, Piaget, Schwab, Skinner, Suchman, Vernon, Wallace and others, that this problematic territory in this decade has sufficiently been explored and consequently problems in this area lie more in the zoo than in the jungle When seen retrospectively, this was hardly the case over twenty-five years ago. The emerging literature on thinking clearly tells that children learn spontaneously and they do acquire schemes of thought regardless of school influence. They learn from one another, and learn equally well in formal situations. Being free and active, they cannot be given a ready made point of view for acceptance unreflectively (28, 63). Also they do come to possess intimately first hand knowledge about men and other affairs in their immediate environment. This however does not amount to saying that the 'sun rises in the east and sets in the west.' It only means that the child's thinking is not at all a case of a random behaviour for it is sensible, intelligible and predictable against the available theoretical constructs (63, 96).

Definition of Concept

Here, it is a case of definitional muddles for concept defies its own definition. The term is easily understood rather than formally described for suiting all occasions and objectives. It is so because it is seen differently by different persons : laymen, teachers, method specialists, educators, psychologists,

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scientists, mathematicians, logicians and philosophers. For illustration, consider the spectrum over which the definitions vary : abstractions, appropriately grouped experiences, assertions, commonality, constructs (physical, mental, both), creations (free as well as restricted), decisions, ideas (created, identified or developed), identity (single instances), inference, meanings, mental images (things as well as actions), processes (active, passive, adaptive), outcomes of instruction, product of scientific processes, terms, thoughts (tool or vehicle), symbols and words (11,50,93). Our difficulties do not end here as there are some concepts, according to Robert Gagne, which are solely obtained by definition : resistance, density and uncle (26). Moreover whether they are concrete or formal, they develop psychologically for they are seen to have beginnings. If so, they can be at variance with tested knowledge. From an association point of view, it is also seen, according to H H. Kendler, as "a set of connections between some response and certain attributes or cues in stimulus pattern" (9). On the other hand, it takes an entirely different context, when it is regarded as an internal construct or cognitive structure which influences overt behaviour. It then acts as a hypothesis which releases behaviour through implicit processes which, in turn, also seem to control overt behaviour. Lastly, a person is said to have formed a concept when he is able to classify, generalize, discriminate and apply it on a pre-determined criterion or criteria.

Functions of Concepts :

As concepts share both logical and psychological characteristics, they appear to serve the following functions :

1. They are constructs which mostly arise from incessant physical encounters with environment. If mental, they

are not open to observation. Still, they are open to identification and naming.

2. They simplify, classify and inter-relate various experiences, events and processes. In this process, they become objective in character which further our knowledge.
3. They render meaningful certain aspects of environment, phenomena, modes of reaction or behaviour, relationships or groups of facts.
4. They inter-connect themselves and constitute a hierarchy.
5. They are practicable, verifiable and usable statements, specifically worded to be true, within their statements. Anomalies, if any, are set right when they (concepts) either contradict one another or an equally well established law.
6. They are economical because they save us from 'repeated learnings.' If forgotten, they can be reactivated easily. Moreover, under certain conditions, they pay us off in terms of transfer and generalization.
7. They are helpful to us in other ways as well. They, generally speaking, diminish our cognitive load. On the other hand, they also enhance it when we try hard to tackle complex problems.
8. They are not immortal. They have their own levels of development Even if considered fundamental, they change with the passage of time when additional research throws up new facts and insights (2,11,12,16,48,50,81, 93).

The Process of Concept Formation

It is necessary to consider the nature as well as the functions of concepts against the backdrop of thinking for they are the gradually 'built up learnings' about our environment.

According to Smoke, these are characterized by 'consistency of differential, generalized and symbolic response' (84). The complexity in this type of comprehensive treatment shows that little is known about how children form as well as utilize concepts. Leaving apart the work of Prof. J. S. Bruner and his co-workers, the same is true about the development of class concepts in adults classified as the 'concept attainment' studies. However there are some ideas which do sum up superficially how concept formation takes place. We not only live in a physical world but in a psychological world as well. Several stimuli comprising objects, events, cues and people impinge on us and we are compelled to classify or categorize them. For example, one need not enumerate all individual animals for the concept of 'animal' does the job quite satisfactorily. At another time, one is led to classify a group of objects, living and non-living, on the basis of attributes. The presence of a particular attribute shows that it is a discriminable feature of that object not at all shared by all the remaining excluded objects. So it is not difficult to classify, theoretically speaking, a given group of objects on two or more than two criteria simultaneously. Concepts thus permeate our thinking. To illustrate : After thunder comes rain or day follows night and so on is a case of association which clearly gets connected over the years. More specifically, a young child calls every approaching old woman his grandmother. According to R. Brown, he does so because he employs a large category which gets smaller and smaller as he builds up more discrimination in relation to this concept (10). The child thus verbalizes, generalizes and discriminates in a wider frame of reference. It is not after all a single shot affair. The child constructs his perceptual field as gradually as he can manage it. It should not be forgotten that he is

badly handicapped by the lack of linguistic ability. At times, he throws the whole of himself into physical activity. He is not at all attracted by the flat pictures but definitely appears to enjoy the tune : He is a jolly good fellow ! If shown a pencil, he stretches his hand towards it and getting it, he begins to suck it. By sucking, rubbing, pressing, holding, stretching, striking and crawling etc., he attempts to further his practical knowledge. A clever observer will find him behaving like Kohler's chimpanzee when he pulls the table cloth to get something edible or attractive lying on the table. Or he puts brick on brick to reach his source of temptation. Initially, it is a terrifying experience for him to see a passing bus, truck or even a car. Then he learns to live with it by anticipating its arrival by associating it with its shrill whistle as well as any of its approaching cues : noise, size, colour and stoppage. In short, he is able to coordinate his movements gradually and with the emergence of a powerful tool, that is, language, he is pretty fast in the formation of concepts. He is, thus, in active commerce with his limited environment and goes on building his own house of knowledge in the midst of satisfying experiences, annoyances successes and failures.

It appears that certain abilities come naturally to the growing children. Price Williams, for example, did not find any difference in abilities to classify known materials between the school going and the illiterate tribal children in Nigeria (62). Ability to conserve a stable conceptual structure appears only within the age group 7-11 years. Classification, seriation and other operations, very necessary in the formation of number concepts, also appear in this period. Failure to conserve led Prof. J. S. Bruner to remark that the words 'same' or 'more' do not have the same meanings for children and adults (23). Even adolescents feel confused when

confronted with situations like the following :

1. Teacher : Who discovered the steam engine ?
   Student : What ?
   Teacher : Say Watt, not what !
2. How many drops do you get when you add a drop to another drop ?
3. How many corners are left when one of the corners of the handkerchief is cut off ?

Concepts, generally speaking, widen and deepen throughout life. Abstract concepts like atom, gene, truth, beauty, goodness and sin etc. are difficult to acquire. Positive instances confirm concepts and negative instances bring out the anomalies in them for reconcilation including their rejection. With or without guidance, children form those concepts first which are of most use to them. Even adults, invariably, also impose their concepts on young children more markedly when they are considered as little adults. Lastly, Piaget is not alone when he says that action is the basis of thinking or thought. Sherrington even went to the extent of saying that our present day mind arose out of motor act initially. Even primitive man first carried out physical acts rather than mental operations in his daily business of life (62).

Discriminant Learning :

It is another variant of learning in the nature of negative component which further complicates the treatment of concepts. It enters into the learning processes at every stage. Like instrumental learning, the principle of reinforcement applies to it. Historically speaking, the work of C. L. Hull offered an experimental method which made it possible to study the effects of numerous variables on concept formation. Secondly, the concept formation was studied in an S-R

paradigm. Thirdly, the neo-behaviourists saw only the following three variables in any psychological event, namely, environment, behaviour and the connection between the two, say, in the form of association. These efforts enabled us to find sense in the definition of concept, that is, a common or shared response to a 'set of dissimiliar stimuli.' Hull thus based concept formation on discrimination, learning, using the principles of conditioning (62,89). Discrimination is involved when a dog responds to a white circle but is made not to respond, say, by denial of food, to a grey circle in the laboratory. Pavlov explained this unusual behaviour of dog in terms of conditioning, stimulus generalization and extinction. The child is able to pick out a blue pencil out of a pencil pack containing pencils of different colours. He, thus sees 'blueness' in relation to other colours. His other responses to other colours must also be extinguished. The problem becomes difficult when it comes to classifying pencils on two other criteria : more blue and less blue. The differentiation here becomes more enhanced. If this would not have been the case, our behaviour would have become very inflexible.

Adaptive behaviour is possible because of generalization and discrimination. If one thinks of 'cheese' then the question arises: 'what kind of cheese ?' because many brands of cheese are available. And here enters discrimination, that is, different responses arising out of several similar stimuli. The spectrum of behaviour narrows down because the earlier stock responses are not reinforced mechanically. Both animals and humans can learn to respond on the basis of their discriminations. It is so, because, according to Hull, learning is a continuous process right from the very first trial. Based upon past reinforcements and non-reinforcements, the

development of simple learning operations makes discrimination possible. Krechevsky has however questioned this 'Hullian cumulative effect' hypothesis in his study on rats where he distinguished two types of attempts in them, namely, exploratory and those leading to solution without continuity (53). Lastly, research efforts are in progress with focus on outside variables influencing concept formation as well as the very basic process of discrimination underlying it.

Mediation Process

It is necessary to refer to the mediating processes because they have been hypothesized to explain certain aspects of abstract behaviour manifested in rats, children and adults. A century of work within the context of S-R framework informs us about the role of reinforcement and extinction in the formation of S-R connections, probability of occurrence of various responses within the response hierarchy and the description of un-observable internal processes in terms of mediating processes (23). The last mentioned ones tend to be retainted because of their utility to the organism. As usual, feed-back plays an important part in their modifications. In this context, the organism ceases to act like a black box when it comes to the aquisition of concepts, skills, problem solving, attitudes, beliefs and purposes etc. Initially, it was dependent upon the environment but at a suitable later stage, it is in a position to organize itself. It can then generate its own stimuli and signs with a view to release appropriate behaviours meeting the varied requirements of the situation, likely to be encountered sooner or later. And then it is least dependent on external stimulations. Interestingly enough, it also gradually learns to short circuit its behaviour for achieving quick results. If the situations so warrant, it is also in a position to anticipate events and take appropriate corrective

measures well in advance of the occurrence of the actual events. So, mediation processes enlarge the area of interpretation of abstract conceptual behaviour and facilitate the transition of S-R theories to cognitive theories. In that case, Max Wertheimer need not declare S-R theory as a case of blind learning because it fails to provide a comprehensive account of human thought (106).

Physiologists also tell us that the human organism has its own past history, capacity, ability and personality including emotional reactivity in which genes and chromosomes play an important part (23). In conditioning, the human subjects do not unconcernedly await experimental stimuli and their contingencies at the hands of the experimenter. On the other hand, they come to him with 'thoughts, feelings, attitudes, beliefs and expectations,' which, according to Lockhart, play critical role in their behaviour (58). It is not difficult to see that the mediating behaviour among humans increases with age which consequently goes a long way in the formation and application of concepts more rapidly than would have been otherwise the case. It is precisely for this reason that children can be familiarized to a considerable extent with an unknown animal through actions, pictures and models etc. under the overall class concept of 'animal'. In the phraseology of Osgood, it is called 'sign of sign' (85). In contrast to this, B. Kleinmuntz views concept as internal cognitive construct which releases external behaviour. This concept is one of the many available with the organism at that moment. (51). According to Levine, reinforcement acts on the implicit process which, in turn, controls the explicit behaviour (55). Whereas children and adults engage themselves in several covert activities, the latter, according to Bourne, have no business to influence explicit behaviour. Why ?

Because, according to him, what the 'organism learns are rules; and behaviour is a rule following enterprise' (9). The organism receives another hard jerk by E. B. Hunt when it goes about the business of making an internal model of its environment. He concedes some form of mediation in the analysis of concept learning but at the same time, finds the mediation hypothesis quite inadequate because of its poor predicability. So the S-R and the mediation models can only account for the learning of simple concepts. For more complex concepts, they do not provide for sufficient 'abstraction and stimulus internalization.' Here a valuable suggestion has been made by Hunt which says that human complex learning is something entirely different in quality from the 'purer (non-verbal) learning displayed by animals.' It is then possible to develop an imaginative learning theory for humans by basing it on new principles and other empirical laws (31, 39) It is a suggestion which is inconsistent with Piagetian thought (79).

Second Signalling System

In the preceding section, reference has been made to the mediational processes which attempt to describe part of the complex behaviour of man : anticipatory behaviour, knowledge and purpose within the conditioning paradigm. The same complex behaviours could not be explained by the classical conditioning as propounded by Pavlov. He, therefore, late in his career, put forward the theory of second signalling system in which he regarded man as verbal being. In this scheme, he uses words which did act as stimuli for releasing appropriate behaviours. Hence, at this stage, the physical stimuli from the external world were unnecessary because man is capable of generating his own stimuli. In a way, these stimuli in an abstract manner represented the second signalling system, which in fact, stood for a multitude of separate stimuli of the first

signalling system. The rule of such second order habits resulting finally in the form of concepts as well as rules in understanding all forms of learning is easy to recognize. According to P. A. Liublinskaya, a word attains the status of a concept only when it becomes an integral part of the second signalling system (57, 101).

Factors Affecting Concept Formation

Workers in the area have indicated several factors which influence concept formation. These factors are : intelligence, age, socio-economic status, grade, vocabulary, nature of the concept, culture, language, structure of the learning environment, manner of obtaining response, desire to learn as well as to succeed, level of attainment, opportunities for application and availability of leisure (50, 56). After having formed their concepts through activities, children may further develop them either through reading or under the influence of the teacher or adult. There is no direct relationship between motivation as well as anxiety and concept development (50). Even threat of failure may act both ways. There is a wide I. Q. range over which a given concept is failed or acquired not only within grades but also across the grades (95). Approach (or strategies) to concept formation is equally important, for a given individual may like to develop it at verbal level or behavioural level (95). Modes of presentation and gradation of conceptual tasks on concrete-formal dimension also go a long way in influencing concept development (54). Increase in irrelevant information as well as negative information also very likely makes acquisition of concepts difficult (9). Lastly, how the concepts are validated go a long way in eliminating illogical concepts (91).

Methods of Studying Concepts

Depending upon the aims of investigation, hypotheses

proposed to be tested, the age, size and nature of the sample, variability in the complexity of tasks and the time consuming nature of test administration in the presence (or absence) of the past history of the individual, one can discern several methods and techniques of concept investigation (56). One can employ the Socratic type of technique in which after initial questioning, the subject looks stupid and gasps for the correct answer. In their day to day teaching, teachers can use informal methods, lacking scientific controls, for investigating concepts among their pupils (91). In the case study approach, a given subject is probed over a certain interval of time where records of questions as well as their answers along with informal observations, if any, are maintained and analysed, later on for ascertaining continuity of thought (71). Free association, analysis of products and discrimination are the other three overlapping methods which have been profitably used by the workers in this area (56). For mapping intellectual development genetically, Piaget has developed and used with success his own method of critical exploration called Method Clinique (28, 97). For measurement of concepts in individual minds, C. E. Osgood and G. A Kelly have suggested two other sophisticated techniques, namely, the semantic differential and the repertory grid technique (47,74). They have varied widely the use of experimental materials : symbols, words (nouns, adjectives and verbs), pupil products (drawing and writing), pictures, sorting tests comprising cards and geometrical figures, picking the odd word out, and apparatuses (including drums for mounting materials, audio-visual aids including tape recorders). Under appropriate conditions, it is possible to obtain further information on flexibility in thinking, pupil's feelings and perseverance (56). Whatever may be the method used either in isolation or in

combination, certain problems abound in regard to the following: insistence or acceptability of the concept, number of acceptable responses for ascertaining the mastery of a given concept, benefit of additional trials to the subject in the understanding of the concept, amount of practice, manner of combining time, error and repetitions and, nonetheless, a detailed listing of underlying behaviour (56). Despite these difficulties, some interesting facts have come to light. Both children and adults do give correct instances even without clearly having understood the concept (22, 27). Sometimes they give the false impression of having mastered the concepts when further probed (78). At other times, to the experimenters' annoyance, they go on giving wrong responses despite the fact they are told not to do so (56). In his book, John Holt came up with two interesting observations. First, children respond to please the teacher rather than meet the requirement of the question. Secondly there is no essential difference between the dull children and the bright children for the former forget before the examination and the latter, after the examination (34).

Studies in Concept Formation

In itself, it constitutes major area of investigation in its own right. When other outside variables are included, it amounts to getting an extra known from an equation connected by two unknowns. Very little work has been done on the evolution of concepts in relation to their functional and quantitative aspects. Few available studies on higher mental processes have suffered from introspective methods, analytic purposes and qualitative results. Hull, for example, investigated 144 Chinese characters. He concluded that formation of individual concepts is a gradual process in which trial and error plays an important part. Concept formation is facilitat-

ed when common attributes of situation are pointed out. A combination of formal and concrete methods is more efficient in the acquisition of concepts than either of the methods taken in isolation (36) Using concepts each having regular and confusion features. Smoke noted that there is some form of 'grouping in concept formation.' Hypotheses are also formed and tested in it (84). Thirdly, subjects feel difficulty in verbalising their concepts even if they had acquired them Using 22 blocks, varying in colour, shape, size, and height. Haufmann and Kassanin identified three inter-related behaviours in the course of systematic conceptual thinking : categorical attitude ; insight, and total consideration of the problem where nature of the task rather than the rules of experiment determines the subject's behaviour (30). Recently, according to Piaget, J. S. Bruner and his co-workers have reopened up a great field in concept formation Using cards, varying in colour, shape and borders, and after having introduced each subject to the concept of conjunctive concept. they have identified four distinct strategies by which a person may form a given concept : simultaneous scanning, successive scanning, conservative focussing and focus gambling (11).

Using factorial approach, Ruth Beard investigated concept formation among infants Burt's group-factor method indicated a general factor and six fairly independent factors relating to physical pheromena, space and ability to reason with quantities etc. Her investigation supported Piaget in principle but added that individual experience as well as cultural influence does modify Piagetian stage concept (6). While not contradicting Piaget's concept of stage, J N. Joshi found sex differences in the understanding of algebraic concepts favouring boys. He also showed that superior intelligence is related to higher scores on the concept tests (45). Using case study

approach and investigating concepts like Constant differences, proportion, generalization to algebraic symbols, formation of problematics situation, insight and framing and testing of hypotheses among certain groups of adolescent pupils matched on intelligence and socio economic status through problem solving approach, N. Vaidya concluded that complex problem solving processes arise from simple thinking processes. Secondly, mastery as well as failure on a given concept is manifested not only within individual grades varying over a wide I. Q. scale, but also across the grades as well. His findings support Piaget in principle, but some intellectual behaviours of the concrete stage do appear during adolescence. To illustrate, they do not exhaust all combinations and possibilities. They are badly affected by the content rather than the form of the problem as well as while tackling problems involving reversibility in thinking. They do not hestitate to magnify the problem out of its proportion by bringing several extraneous situations into it. Moreover, adolescent pupils below the age of 14 years lack schemes of proportion and generalisation to algebraic symbols. Whereas they are in a position to set up hyphotheses, most of them below the age of 15 fail to test them through controlled experimentation. Contrary to Piaget, their minds have not yet become truly experimental (95,97).

Let us consider another group of studies. Maier had shown earlier that the mere presence of needed background experience in itself does not guarantee success during problem solving. He therefore gave the concept of direction which was attacked fiercely by K. Duncker because it was covered in his reformulation or restatement of the problem (65). In another interesting study, Szekely attempted to investigate 'Knowledge as the starting point of independent thinking.' He found, not only that knowledge gets reorganised in the

process of thinking but also, stress on rote memorization of definitions and facts is hardly helpful in solution (88). In another study, Mealings found that there appears to be a minimum mental age of 13 years before pupils can reason formally about a problem Regarding theoretical and abstract problems in science, they must attain the mental age of 16+ (68). Butts is very close to Piaget when he asserts that meaningful concepts will emerge automatically when children are provided with appropriate experiences freely (14) G. Stanley Hall, before the beginning of this century, possibly talked of the same while studying the contents of childrens' minds. He suggested that teachers should converse with children about common things (29). Fleshner also firmly shares the same view-point (92). Researches of N.E Weaver & E.N Madden too have advanced two conditions for problem solving, namely, possession of relevant knowledge and the mastery of research operations. They refer to an interesting finding where 80 percent of the subjects thought that those bodies which could not be put on the scales did not possess weight (92). Goriachkin also makes a similar point when he says that children should develop concepts from their own living experiences (92). Here, Stendler is more specific when he stresses the role of structured experiences and models in acquisition of concepts early in life because they might contribute for the building of a neural reservoir (86). In another interesting study on the development of scientific and mathematical concepts in primary school children, it was found that urban children were 'faster' in concept acquisition than rural children Whereas the urban and the rural groups found the concepts of number and weight easier respectively, both the groups found the concept of energy too difficult (5). In her doctoral study, U. K. Bavli attempted to investigate

the 'level of development of concept of speed in Indian children coming from different types of environments and see if a specifically devised training programme could accelerate the acquisition of this concept'. The sample in two parts comprised 725 children at 6+ , 9+ and 12+; and 268 children at 6+ and 9+ respectively drawn from three distinct areas : rural, urban disadvantaged and urban groups. She found that whereas the sequence of development of this concept remained more or less the same as found by Piaget in respect of Genevan children, differences were found in respect of the level of concept developed as well as its rate of acquisition among the three groups. Interestingly enough, a delay of 2-3 years was also noticed between the Western children and the advantaged Urban Group on this concept. Training had negligible influence on the acceleration of this concept in the context of non-conservation to conservation dimension (7) In another unpublished study by the same author, the effects of home, school and certain selected individual variables on the cognitive development of 664 children at ages varying from 5½ to 6, 6 to 7 and 9½ to 11 years on the concepts of number, length, quantity, area and volume were found to correlate highly with intelligence, socio-economic status, language development and ethical values. She further concluded that language not only plays the most important role in success on conservation tests but also takes the prime position in comparison to intelligence as the 'predictor of cognitive development' (8).

It is given to Piaget to speculate in several areas of knowledge simultaneously and inter-relate them in his own characteristic style as he goes along happily on his epistemological journey. The concept of physical causality is a case in point which arose

out of his earlier work which he further clarified by investigating concepts like : 'because, therefore, why, absurdity, sun, moon, star, river, cloud and other problems and experiments, machines not excluded'. He then asserted that orientation towards causal explanation is characteristic of the entire cognitive life of children. To illustrate, the correct movement of cloud is understood by children in stages at about the age of nine. Earlier, they attributed its movement to themselves, man and God; self moved as well as moralistic; and lastly, pushed away by wind which came out of the clouds themselves. He discovered seventeen types of causal explanations in their thought (25, 77). In this context, several workers like Banks, Dennis, Deutsche, Haung, Isaac, King, Long, Navarra and Welch investigated causal thought among children as well as adults in certain cases. All these studies contradict stage concept of Piaget and also find his classification of seventeen types of explanation of little value. They used questions, problems, and simple experiments relating to natural phenomena and showed that the same child did manifest varying types of behaviour (18, 19, 42, 49, 59, 105). Oakes, for example, found that all age groups, regardless of mental ability and grade, gave all sorts of answers (73). Banks who studied the development of thought of low I. Q children, noticed "age and science teaching had a greater effect on the ability to draw conclusion than did I Q. but those with high I. Q did better in the number of the explanations in the higher categories" (3). In another interesting study, Navarra investigated the conceptual development of his very young son. His evidence indicated gradual development as well as gradual differentiation of expectancies and maintained an inquiring attitude (71) Haung even experimented with strange phenomena comprising tricky situations and reached the same conclusions (31). V. Syamala in-

vestigated the growth of concepts like dreams, thought, God, beauty, birth, as well as death and the origin of things among Hindi and Telugu speaking children respectively. She found that there is no correlation between age and the selected concepts except life, and family relationships. However differences in mental age, socio-economic status, educational facilities and other environmental influences do influence concept development (78). In another study, D. Joshi, found that girls excel boys on concepts like social, aesthetic and time and lag behind boys on concepts of weight and space (44).

What do the above mentioned studies signify ? They signify three sets of fundamental variables which possibly influence concept formation : learner characteristics, task characteristics and environmental features. The role of each is little understood because each is yet to be studied in its widest variation over a sufficiently long time in the context of the past history of the individual. Sex differences in concept development further need explication (97). In causal reasoning, Piaget's concept of stage is contradicted by several studies. But is the same sequence of concept development actually maintained by all pupils everywhere as hypothesized by Piaget ? The firm data in this direction have yet to be forthcoming. Until clarifications emerge in this problematic territory, the role of adult intervention is likely to remain un-understood for a long period.

The Geneva School

Its chief advocate, Jean Piaget, while still remaining a firm speculator, succeeded in psychologically tackling an age-old problem as enunciated by Plato : "How and when can man be sure of his knowledge, when time and again he finds that what he took to be knowledge has proved to be er or" (63).

In this, he not only substituted the fairly well established scientific procedure with his own Methode Clinique, but also constructed his own symbolic logic for interpreting intellectual operations as they develop in stages from the very early childhood to late adolescence (25). He, thus, showed how a child, nay, a 'universal child', goes about the business of constructing his own house of knowledge. Over the last forty years, he and his co-workers have contributed abundantly in the following areas : causality, genetic epistomology, geometry, language, logic, moral judgment, motion, number, object, perception, quantity, space, speed and time. In his entire work, one can easily identify the following three basic postulates: First, every human organism possesses a characteristic internal organization. Secondly, this goes to provide unique mode of invarient functioning. Thirdly, there is an active interaction between the organism and its environment from which stem intellectual structures (25). Intelligence is seen in terms of operations. Through adaptation (assimilation and accomodation), the reflexive actions become interiorized in due course of time Like L. S. Vygotsky earlier and J. S. Bruner, later on, Piaget also propounded stage concept in intellectual development (23). These are : Sensory motor period, pre-operational period, concrete operational period and formal operational period.

1. The Sensory motor period : (birth to 2 years). It is the first stage of intellectual development. In the first half of this period, the child's activity is centred on his own body. In the second half, the child develops schemes of practical intelligence which enables him to deal with objects in space. The child is highly dependent upon his parents for satisfaction of his physical needs, performs only overt activities, appears to throw the whole of himself

physically in the activity, thinks least about his actions, is attracted by sound, touch and other physical stimuli, and while crawling, he is on a voyage of discovery. Flat pictures do not attract his attention but if he is given a pencil, he can stretch his hand to grasp it.

2. Pre-operational period : (2 to 7 years). Piaget calls this a period of representational intelligence because the child is able to represent reality as language and mental imagery. The child sees things in his own frame of reference, can think of only one idea at a time, uses language in a limited way carries on conversation with himself and tends to become less and less self centered gradually. His social interests begin to widen. His thinking is governed by the perceptual considerations of the situation. So his reasoning during this period is transductive.

3. Concrete operational period: (7 to 11 years). The child engages in the activities of the mind which Piaget calls 'operations' which are interiorized and also reversible. The child's thinking is tied to the concrete situations, begins to attack problems systematically but cannot find mathematical proofs, does not accept hypothetical data, reality dominates his thinking and the possibility is subordinated to it.

4. Formal operational period : (11 to 15 years). The adolescent acquires adult capacity for abstract thought. His thinking is no longer tied to the concrete situations. He imagines and considers all sorts of facts, beliefs, hypotheses and possibilities. He develops the ability to reason by hypothesis. He goes even to the extent of finding empirical and mathematical proofs for his observations (96).

Children may not show these stages within the age-ranges specified above, because of differing home and school environments. But what Piaget insists is that the sequence of these stages in intellectual development remains the same for all children, a grand hypothesis still needing confirmation (79).

The work of Jean Piaget as reported by Good (107) is not only extensive but also intensive. Equally true, it is very rich in detailed observation on child as well as on adolescent thought. He has documented the characteristics of concrete as well as formal stages of mental development. At the concrete stage of development, he has also collected research information about the attainment of various concepts at the various age levels. This interesting information is reproduced in Appendix I.

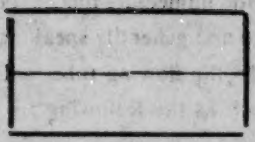
Two Illustrations

1. Conservation judgment Children, and less frequently, adults, do remark when asked an age-old question : Which is heavier : one kg. of iron or one kg of cotton ? And why ? One kg of iron is heavier because iron is heavier than cotton. Or, one kg of cotton is heavier because, in comparison to iron, it occupies more space. The reason for this is that their thinking is governed by the perceptual considerations of the situation. They only see or take into consideration one aspect of the problem at a time. They think from particular to particular. Perform the following two activities with children individually in the age group of 2-7 years.

(i) Ask the child to pour equal amounts of water in two beakers A and B. Let him ensure equality in any way he likes. Then transfer the contents of beaker A and B into the

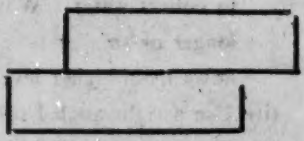
dish C and the narrow tube D respectively. Now ask him the following question : which contains more water 'dish C or the narrow tube D' ? Ask for reasons underlying his judgment. At the pre-operational stage, he says that the narrow tube contains more water because it is higher (or because the dish is very flat). Now, ask him to transfer back the two liquids respectively to beakers A and B. Does he maintain the equality of water ? Does he deny it when the same experiment is repeated by him ? Why does he hold two contradictory judgments at the same time ? The reason for this, according to Piaget, is that he has not yet mastered the scheme of conservation (25).

(ii) Take two pencils or sticks and place one over another end to end as shown. Let the child ensure that these two pencils are of equal length before the start of the experiment. Push one of the pencils sideways. Now ask which one of the pencils is longer ? And why ? Restore the original situation. Does he mention equality in the lengths of the two pencils ? What are his reasons ? Piaget has devised many such experiments which relate to conservation of physical quantities : Solid, liquid, area, weight and volume. From these studies, he comes to the conclusion that such children do not show reversibility in thinking which is acquired



Two sticks coinciding end to end

The top one moved towards left



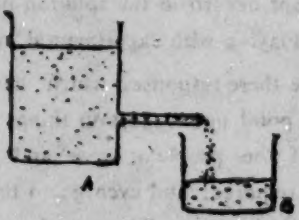
Direct attention to right as well

at the next stage, that is, at the concrete stage of mental development. Here also, children can carry out actions or activities to give further support to their reasonings. But still they require a lot of concrete support for their thought.

2. Excluding variables. Show the following experimental arrangement to your pupils, preferably one at a time. Then raise the following two questions in turn :

   (i) On what factors does the collection of water in the beaker B depend ?

   (ii) How will you study the influence of the following factors : the length of the glass tube, size of the hole and level of water ?



The children below the age of seven fail to set-up con-

trol experiments. At the immediate higher stage, they describe the experimental set-up and generally speaking, do remark that water passes through the flowing tube. They are also seen to make comments such as the following :

(i) It is not necessary to use apparatus You are going to collect water. Why not use syphon ? You take a longer or smaller tube in length, I see that the water flows from higher level to a lower level.

(ii) Use a right-angled tube.

(iii) Do you see air bubbles ?

(iv) Be careful that the tube is not kept slanting.

(v) You see the hole in there, otherwise, how can water flow ? Now see that the clean water is coming out. The presence of water is very essential in this experiment.

(vi) What is the weight of this beaker ?

(vii) What is the length of the glass tube ?

Other behaviours noticed in them are :

(i) Reproducing the question partially or fully in writing, repeating the question orally, trying to collect water or play with it.

(ii) Supplying the information like : This is a beaker or a glass tube. The beaker is round. The glass tube is 15" long Giving a formula and method not needed in the solution of the problem.

(iii) Playing with experimental materials.

They give these responses which have no business to be there. They point out to certain things (air bubbles); suggest a way out of the problem; give and demand information which is not required; and even go to the extent of reproducing part of the question. These are known as arbitrary errors.

They can be educated out of this only if they sufficiently interact with the material. According to Piaget, they behave this way because their basic concepts in relation to the problem under study have not yet developed.

Consider the following response given by a pupil of Class VIII (under 15 years). Remarks by the experimenter are placed in brackets or a bit away from the running text.

Looking thoroughly at the experimental set up. Then says :

Water is coming out of the larger beaker into the smaller beaker.

You know that water always flows from a higher level to another level.

Hesitates for some time and then says :

If no length, no water will be collected.

Now, laughs because the problem goes. I mean length can change.

No, I mean hole.

It can be small, medium and big.

If the hole is larger, water level in the larger beaker will fall quickly.

Can show you this, if you wish ? (No, you need not)

The problem is how I can show this to you.

I will proceed as follows :

Take two tubes (Yes you are correct)

If I have the large tube and fix it there, water will come out. (Yes)

If I fix the smaller one, the water will come out a bit soon. There is going to be a small difference in time.

So smaller the tube, sooner the water will come out.

(Now thinks ! then says that my problem is to find out

whether length plays an important part in the amount of water collected).

Give me some time. Ask: What is this ? (This is a watch, I have told you earlier).

I am a fool because the water has to come out of the two glass tubes.

Now I think I can solve the problem like this.

If longer tube gives more water to the collecting beaker, then I can say that length is an important factor. If amount is the same, then length has nothing to do there.

Similarly, he gives an experiment for isolating the factor of hole. Now he comes to the end of his wits. If I increase the size of the hole, the level of water falls down immediately. If I take the other tube (with smaller hole), it takes time for the water to go. Level of water falls down slowly and slowly. Water level fell in other experiments as well (while isolating the factors of length and hole). Thinks ! Plays with his pencil. I think this factor has nothing to do because water falls down any way. I think that the first two factors are important (95, 97).

What does the above record show ? It shows that the pupil commits arbitrary errors as he goes along with the problem. He observes anything interesting which may provide a false lead (level of water fell). He finds sense in this observation while in the process of linking this observation with other observations. He is able to identify two variables, and succeeds ultimately in suggesting two control experiments. The third, at least, equally observable variable: level of water is missed by him. The lesson of this exercise is that teachers should develop sensitivity as well as respect for pupil's thought when they carry out individual dialogues with children who

vary in intelligence and achievement. It is through a path somewhat similar to this that he reaches fairly well the formal stage, in which possibilities rather than activities of real situations dominate his thinking (25).

There is a distinct difference between the concrete and the formal stage. At the former stage, all intellectual efforts are expanded and intensified on the horizontal plane. Extent of thought was firmly tied to the concrete situation, and was verified or even tested within the context of the experimental situation. But, at adolescence, thinking goes beyond the immediate present, and attempts are made by the adolescent pupils to establish as many vertical relationships as possible. Notions, ideas and concepts are formed which belong to the present and future. All sorts of hypotheses and possibilities are considered and their implications deduced as well as tested for relevance or irrelevance. Even minute details are not at all ignored. At about the end of this period, the adolescent pupils manifest maturity of thought for they can use symbols in their operational thinking. In short, they think by applying symbols of thinking or to put in other words, they develop concept of concepts, a sort of second and third order reflection. To illustrate, it is at this stage that the adolescent pupil is about to develop a high logical answer, as shown by the following reply to the same experimental problem already posed

> I can see 3 factors. These are: length of the tube, size of the hole and the level of water in the large beaker. For the first factor, I will take three glass tubes of different lengths but their holes should be of the same size. I will also keep the level of water same before starting the experiment. In each of these three cases, I will collect water exactly for 10 seconds. Now what I mean is that

the time should be kept constant. Now I am to make a judgment In case, the amount of water collected is the same in all the three cases, length is of no consequence. If amounts are different, I can make my judgment accordingly. The influence of the other factors can be found out similarly.

Let me think ! (Thinks !) I am supposed to set up the experiment in such a manner that I keep two factors the same except the one whose influence I wish to judge. I need :

(i) Three glass-tubes of different lengths but having similar holes (same size).

(ii) Three glass tubes of same length but different holes.

(iii) Water level can be adjusted.

Then he sets up an experiment each to suit the requirement of the problem (95, 97).

The work of Piaget has been criticized on several grounds. First, he does not make his terminology quite clear to his readers. Secondly, he is too much preoccupied with numerous epistemological considerations. Thirdly, his Methode Clinique is not only exploratory and subjective but also difficult to apply. Fourthly, his entire work lacks scientific methodology as conventionally understood. Clarity is still needed regarding the synthesis of classes and relations into numbers; psychology of operational structures as they enter the cognitive life; relevance of too many hypothesized intellectual structures in each scheme; and finally, the manner of influencing interiorized actions in case such a possibility exists (29, 95). Granted this, Piaget does provide superior explanations for the formation of advanced concepts. Why ?

Because he does not investigate nominal concepts like colour, form, shape and fruit etc. Instead, he deals with concepts of relationships (60). Lastly, Piaget considers action as the basis of thinking, which behaviourists had reduced, strictly speaking, to internal speech. Similarly, sensations being subjective, do not constitute the foundations for scientific thinking. However, structure between sensations can be expressed in logical terms which enter into thought through the medium of actions (54). In other words, mediation and language are no longer at the heart of reasoning. Further, logical structures are independent of language content. Here, Jerome Kagan adds that it is first necessary to clarify the definition of logic as well as logical structures imagined by Piaget at the base of conservation (46). He appears to forget, that of course, there being no conservation, either of beauty or goodness, children's thinking, according to Piaget, is definitely guided by invariance principles which have links with mathematics (46). Lastly, all will agree with Kagan that studies are still awaited for clarifying the role of causal factors like semantic structures, different habits of perceptual analysis and different logical structures which gradually give rise to developmental differences (46).

Acceleration in Concept Development

Once we understand a process of thought, it becomes natural to test whether it can be accelerated or not. The evidence is not yet final either way. According to Vygotsky, concepts do not exist like 'peas in a bag'. Higher concepts control lower concepts. He further says that 'instruction precedes development So, planned instruction can accelerate mental development (101). Even having different theoretical standpoints, Prof. Max Wertheimer and Prof. J. S.

Bruner make a similar point (12, 106). The work of Z. P. Dienes on the attainment of specific mathematical concepts underlying the processes of abstraction and generalization is also a pointer in that direction. Sometimes children at lower stage of mental development do give correct formal responses which, on further analysis, appear to exhibit 'shadow actions' without any logical significance of various events (20). Employing the combined use of experimental, statistical and introspective procedures, Wheeler not only confirmed Burt Isaac but also showed that 'most of the elementary schemata necessary for valid reasoning are already within the control of seven year-old children' (104). Using a teaching machine Keisler and Mcneil showed that children come to learn abstract scientific language as well as provide correct explanations for specific events underlying atomic theory (67). The experience of Head Start Schools in U.S.A. is also a case in this direction where environmentally handicapped children under expert guidance before the age of four or five succeed to extract meanings from statements. This achievement has become possible because the youngsters begin to experience success early in their lives (32). When logical operations are taught, findings of Hyram and Morf. favour acceleration of concept development (40). This finding is not supported by Lovell, Ogilvie and Dowddell (103). E. A. Peel here adds that we should not forget that young children depend heavily on 'concrete experience, expression and judgment' (75). According to J. G. Wallace, the problems in this area are many : philosophical, psychological and technical (103). Lastly, a suggestion of value has been made to teachers by W. D. Wall in England, that is, they must distinguish between the 'Logi-

cal structure of a subject, process or technique and the psychological mode in which it is taught' for even content remaining more or less the same, the psychological processes involved are different (102). In conclusion, training is assumed to be helpful in acceleration of thought processes under certain conditions which need to be specified more and more concretely as well as specifically. Finally, the question arises whether the newly generated processes belong to the chips of the same block or different blocks.

Information Processing and Decision Making

Like any other science, it is also the purpose of psychology to develop meaningful patterns of descriptions, explanation and prediction through a series of constructs (94). The growth in the concept of electron over the last hundred and fifty years or so is, for example, a case in point (94). Information is a basic commodity which flows through certain communication systems like telephone, telegraph, wireless, automation, control system, economic system and even the human body and brain (64). So, the chief aim of information psychology, according to H. Frank, is to attempt to use 'Cybernatic-approaches, methods, measurements, and models in psychology' with a view to development of a psychologically apprehensible picture of man (22). For our limited objective of understanding human behaviour in stages, it is possible to regard concept learning as an information processing problem (37). It is so because the human being, having a long-term as well as short-term memory, stores, receives and processes information to generate concepts, generalizations, hypotheses and deductions (27). Language also plays an important role because it is used for communication.

So, a tool has come handy for studying complex intel-

lectual tasks in their multivaried aspects at high speed and efficiency through a series of models which are made to click (27). In this process are also surmounted those problems which are difficult to solve in the laboratory. Computers are now capable of using highly sophisticated methods for problem solving which can be hardly used by humans: 'Markov chains, Bayesian decisions and inverse probability' which may throw light on the structure and functioning of nervous system (27,39). On the other hand, it is also possible to simulate certain aspects of human thinking. It has now been seen that the comparisions between the two solutions obtained by human mind and computer are very interesting. If programes succeed, the simulation approach, at its best, could further advance our knowledge about how people tackle specific jobs which may completely change our picture of man as active executor of information processing (38). Rather than remaining passive bundles of stimuli and responses, successful simulation will throw light on shifting strategies as they finally develop against the backdrop of demands made by the external and internal environments as humans achieve increasing level of individual functionings.

Interestingly enough, intelligence test items can also be simulated and strategies employed by humans could be further examined for educational purposes (38,43). Using specific concepts, Hovland gave a communication analysis of concept learning in which the efficiency of the information processing of humans could be measured (34). If strategies are considered short-cut methods for problem-solving, then, it is again possible to see unit of search in terms of TOTE (Test, Operate, Test Exist) as against S-R bond in the S-R theory (56). According to Hunt, it is possible to analyse cognitive

processes using this concept (37). It is also possible to gauge the internal stage of the receiver by making a transition 'from the concept of statistical analysis to that of subjective information'. Thinking along this line has led to the development of high speed computers which are very helpful both to the research scientists including mathemticians, and psychologists in several ways for solving problems in an open frame of reference by organisation of data, reduction of data and setting up of hypotheses and their testing by modelling and simulation as well as synthesis (24, 39). The success in this area depends in having an open monitering process continuously which enables us to understand, explain and predict human behaviour in all its varied aspects as we go along on our voyage on hypothetically picturing man psychologically from as many varied points as practically and theoretically possible. If baffled, a new model of behaviour is imagined, developed and tested until success is attained. If bluffed, evaluation on both internal and external information sources, internal environments, or internal models would no longer remain barred even in the overall larger context of transformation of information and its coordination, a distinctive quality of human mind as revealed by the Geneva School (41).

Summary

Whereas the present review covers the area of concept formation in all its varied aspects, it also at the same time uncovers the problems in this area in the hope that their solutions will be the major achievements of the next two decades of this century. Any review, however exhaustive it may be, is bound to have certain infirmities. If liberty is taken, it is more important to organize questions in this area than obtain a few isolated answers to certain questions

even under controlled conditions. If there is too much diversity in concept of concept as well as function, and technique of investigation etc., it is necessary then to challenge the fairly well established body of scientific knowledge imaginatively even by entertaining the most funniest ideas which are woven partially by joining part fragments to each other like fibres in a long rope. What are those questions like :

1. What is the place of concepts in thinking ?
2. What is a concept and how does it function ?
3. How do they singly or otherwise organize themselves at different levels of development ? Do they constitute a hierarchy ?
4. How do the various learning theories illumine the various aspects of concept : formation, attainment, development, utilization, availability and naming ? The distinction among these words needs to be made more and more sharp than is otherwise the case to-day.
5. What exactly is the nature of causal reasoning ? How do the children and adults acquire concepts during conversation ? And also how do they further their own thoughts ?
6. Piaget appears to say something relevant to the education of children. His ideas can be applied in the education of adults, especially those who have not yet achieved the formal operational level. If the Piagetian ideas are further probed the non-formal education may derive immense benefits. Piaget has provided us information about concepts characterized by mathematical relationships. However we know very little about how abstract concepts like : truth, beauty, goodness, trustworthiness and sin etc., develop, in which there is no conservation.
7. Does unitary ability or stage exist for formal operations ? Or is it different for different tasks ? Does adult or teacher intervention improve affairs ?

8. Is it necessary to synthesize the varied theoretical standpoints drawn from the various learning theories: Conditioning reinforcement, probability learning, insight, grouping and regrouping of thought, accomodation, assimilation and acceleration etc ? Other mathematical models of thinking can also be considered. If so, a powerful approach for the analysis of complex concepts may ultimately result.

The present review discusses : Definitions and Functions of Concepts, Process of Concept Formation, Discriminant Learning, Mediation Processes, Second Signalling System, Factors Influencing Concept Formation, Methods of Studying Concepts, Studies in Concept Formation Geneva School, Acceleration in Concept Development and Information Processing and Decision Making. The ideas contained therein suggest that the organism lying between the stimulus and the response need not at all be sacrificed at the altar of behaviourism. It has its own distinct personality or internal environment. The organism at some stage of its development begins to contribute to its own autonomous behaviour.

It is yet to be seen whether adults have sharp hypotheses in their minds before testing them. According to Bourne, they have no business to be there because 'behaviour has to be rule following enterprise' (9, 80). E. B. Hunt goes a step further when he says that S-R mediation models do not adequately provide for sufficient 'abstraction and stimulus internalization' and hence only suitable for simple concepts. According to him, it is within our possibility to develop an imaginative learning theory for humans by basing it on new principles and other empirical laws (37). It is a suggestion which is inconsistant with Piagetian thought. Equally well we are to learn from the interesting interpretations in this area from the neurophysiologists (33).

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APPENDIX—I

Characteristics of Abstract as Compared to Concrete Thought

Concrete Operations	Formal or Abstract Operations.
1. Classifications and serial ordering are employed in a step-by-step fashion, without relating all of the links into a system.	1. Reasoning now begins with propositions and hypotheses. A system of what is hypothetically possible is structured and followed by empirical verification.
2. Well-mixed variables in an investigation cannot be separated.	2. Factors or variables in an experimental setting are now seen as distinct and can be separated from one another.
3. Logical multiplication of factors is limited to 1 to 1 or 2 to 2 correspondence but a total n to n system is not yet available.	3. A complete combinatorial system is available so that all combinations of factors n to n) can be exhaustively tested.
4. Reversibility in operations is limited to negation or reciprocity but they are not interrelated as a system.	4. Reversibility is advanced by the inter-relationship of negation and reciprocity, resulting in the ability to maintain a dynamic equilibrium in a system involving many factors.
5 Experimental variability is seen as a result of multiple causes and no systematic efforts are made to isolate and control factors or variables.	5. Variables can now be controlled systematically.
6 Chance or probability ideas are influenced by previous results, yielding a kind of 'gambler's fallacy.'	6. The notion of probability becomes operational and widely applicable.

7. The notion of correlations is incomplete, and errors occur when anything other than simple relationships are involved.

8. Proportions are not as yet available except in the simplest sense.

9. Experimental contradictions cannot be pursued in a systematic manner.

10. Conservation is limited to those physical qualities that are easily tested.

11. Thinking is a derivative of the child's own actions on concrete reality.

12. 'Models' represent the concrete reality that seems to be offered rather than abstract possibilities worked out by others.

7. Correlations are no longer limited to 1 or 1/2, but are, at least qualitatively, also applicable in such situations as 1/6, 2/7, 3/11 and so on.

8. Proportions are now much more widely applicable in solving problems.

9. Because of the complete combinatorial system, experimental contradictions can now be isolated and solved.

10. Conservation is no longer limited to the immediate, testable environment.

11. Coordination of reference systems is possible and acceleration is worked out.

12. In an experimental situation involving many variables, logical pairs are sorted out and tested.

13. The utilization of a proof based on 'all other things being equal' is now pursued.

14. The binary system of propositional logic based on the operations of conjunction, disjunction, implication, and others is operable.

15. The INRC group transforms the binary system into a fully operational, interrelated system.

Concrete Development	Age Range
Classification	
a. Intentive-extensive coordination	7-9 yrs.
b. Stable classification criteria	7-9 "
c. All-some relations	8-10 "
d. Class inclusion	9-11 "
Seriation	
a. Simple series	5-7 yrs.
b. Insert elements into series	7-9 "
c. Analyse elements using whole series shape	9-10 "
Number	
a. Conserver	6-8 yrs.
b. Coordination of ordinal and cardinal properties	7-9 "
c. Singular class	8-9 "
d. Null class	9-11 "
e. Multiplicative classification	10-12 "
Topology	
a. Rhombus reconstruction	6-7 yrs.
b. Linear and circular order	7-8 "
c. Knot tying	8-10 "
d. Continuity	10-12 "
Projective Geometry	
a. Straight-line construction	7-8 yrs.
b. Perspective	8-9 "
Simple objects	10-11 "
Complex structures	
c. 3-D Visualization	7-8 "
Simple structures	10-12 "
Complex structures	
d. Shapes from cutting solids	
Simple	7-8 "
Complex	11-12 "

Euclidean Geometry	
a. Water-level conservation	9-11 yrs.
b. Conservation of parallelism	9-11 ,,
c. Conservation of angles	10-12 ,,
d. Metric proportions	12-16 ,,
Length and Distance	
a. Conservation of distance (empty space)	7-8 yrs.
b. Conservation of length (filled space)	6-8 ,,
c. Interation of length	8-9 ,,
d Subdivision of straight lines	
Staggered but equal	7-9 ,,
Staggered but unequal	8-10 ,,
Area	
a. Conservation of area	8-11 yrs.
b. Measurement by interation	8-11 ,,
c. Measurement by superposition	9-11 ,,
d. Perimeter-area relationship	12- ,,
Volume	
a. Conservation of internal volume	9-11 yrs.
b. Conservation of displacement volume	11-15 ,,
Coordinate systems :	
a. Generalised reference system	11-14 yrs.
b. Angle measurement	10-12 ,,
Time and Motion	
a. Co-seriation of sequence and duration	8-10 yrs.
b. Succession and simultaneity	8-10 ,,
c. Transivity of equal or unequal duration	8-10 ,,
d. Time measurement	
Linear motion	9-10 ,,
Circular motion	11-14 ,,
e. Relative speed	11-14 ,,
f. Conservation of uniform speed	10-12 ,,
g. Acceleration	12- ,,
Mass, weight and Density :	
a. Conservation of continuous quantity	8-10 yrs.
b. Conservation of weight	10-12 ,,
c. Density	12- ,,
d. Weight distance equilibration	12- ,,

APPENDIX 2

The Problematic Territory of Jean Piaget and Adolescent Thought

Introduction :

Since man has always been a ceaseless enquirer into scientific, technical and social studies, his concern for the development of children, teachers and teacher-educators is growing in importance. Educational ideas, like scientific probings, did not develop in a vacuum, and they have their principles 'rooted in the wisdom of the ages,' traced back to the ancient Greek thinkers like Socrates and Plato. Since then the ideas of many great thinkers, representing different disciplines, have been woven into the fabric of current educational philosophy and practice. And Jean Piaget drew heavily from this great philosophical reservoir. While doing so, he appears to have paid back his ancestral debt abundantly in his own lifetime. For it is impossible to imagine today a cognitive study without any reference to his work. Whether one agrees or not, a dip in the 'Ganges' of Piaget does affect one's outlook on educational problems. Why ? Because he presents a series of challenging syntheses as obtained in the rationalist tradition of Plato, mental categories of Kant, the Bergsonian notion of perceptual change, the findings of Gestalt psychologists like Max Wertheimer, the use of logic for interpretation of thinking (classes, relations, grouping, reversibility and equilibrium), and in the revelatory statements made by personalities like Calvin, Rousseau, Pestalozzi, Claparede, Binswanger, Bleuler, Rorschach, Meili, Jung, and Sechehaye (1).

Philosophical problems present themselves to the philosophers, perhaps in the true tradition of their beloved field of enquiry, in unsolvable form (3). Piaget, while still remaining a firm speculator, succeeded in psychologically tackling an

age-old epistemological problem as enunciated by Plato: "How and when can man be sure that his knowledge is true knowledge, when time and again he finds that what he took to be knowledge has proved to be error" (1). In this, he not only substituted the fairly well-established scientific procedures with his own *Methode Clinique*, but also constructed his own symbolic logic for interpreting intellectual operations as they develop from the very early childhood to late adolescence. He thus showed how a child, nay, a 'universal child,' goes about the business of constructing his own house of knowledge. Continuously challenged by this problem over a period of forty years, he came up with this grand hypothesis:

Development is continuous not only within the individual but throughout all evolutionary levels. From the biological to the social to the intellectual levels, the unity of nature is preserved. The functioning of the loveliest mollusk is based upon the same fundamental processes as that of an Einstein (2).

The Nature of the Problem

Thinking is a 'ghost'-like activity, for it has to be inferred rather than observed. In literature, it has been referred to as abstracting, analysing, comparing, deducing, defining, discriminating, estimating, generalizing, guessing, imagining, judging, knowing, opining, reasoning, recalling, for conclusions and understanding." While going ahead, one has to cross the territory of 'concept formation,' which again turns out to be a vast area of investigation in its own right, having strong links, but not icential with, such complex psychological processes as thinking, learning, problem-solving, language acquisition and symbolic representation. If this journey is further continued, one enters the complex areas of problem-solving, creativity, critical thinking and

originality, where one is usually caught in a quicksand pit of definitional difficulties. One is very lucky, if for every milligram of information, he spends a quintal of effort. And at this point the distinction between original sense and original non-sense disappears.

Not long ago, the nuclear scientist Oppenheimer aptly remarked: "It is the business of science to go wrong." Difficulties for the cognitive psychologists, therefore, go on multiplying, and for achieving success, problems have to be posed more and more productively in the phraseology of Gestalt psychology with a view to investigating the complex processes of thinking, which may ultimately lead to the development of understanding, generalization, discrimination, concept development and attainment. The problems, however, do not end here, because the researchers and the practitioners do not invariably ask the same questions. These split-questions, and possibly the consequent split answers, are bound to appear in the business of any science, educational psychology being no exception. The workable solution under these circumstances lies in considering the two in isolation as is frequently done in meeting the anomalies in science. The basic problem here is to relate the most significant concepts of science to the mental development of children whose answer goes a long way in providing the psychological structure to any one of the school subjects. Thanks to the recent efforts of Ausubel, Bartlett, Beard, Bruner, Flavell, Gagne, Guilford, Hans Furth, Hearnshaw, Humphrey, Inhelder, Lovell, Lunzer, Peel, Kraplus, Piaget, Schwab, Skinner, Suchman, Vernon, and Wallace, the problem-territory in this decade has been sufficiently explored and consequently, the problems in pieces—like the discovery of fundamental

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particles in atomic physics—lie more in the zoo rather than in the jungle.

This was hardly the case over twenty-five years ago. The emerging literature on thinking clearly tells us that children learn spontaneously, and they acquire schemes of thought regardless of school influences. They learn from each other, and learn equally well in formal situations. At the same time, they also possess first hand knowledge about men, and their affairs in the immediate environment. This, however, does not amount to saying that the sun rises in the east or sets in the west It only means that the child's thinking is not at all a chance or random behaviour. It is sensible, intelligible and predictable against the available theoretical psychological constructs (3).

Problems Posed in the Field

In this perspective, the field as a whole poses the following problems which overlap each other to varying extent :

1. Specifically speaking, what are those conditions under which learning takes place maximally ? What exactly is the role of hints and clues either in supporting thinking or in the formation of concepts ? To what extent can concepts be downgraded ?
2. At what age is formal reasoning manifested among different categories of pupils ? How is formal reasoning different from concrete reasoning ? What are the conditions that determine transition between the two stages ?
3. How is thinking generalized in each of the two grades ? Does it develop in stages ? Is it possible to accelerate the stages ? What is the role of planned experiences in concept development and problem-solving ? Is creative thinking also influenced as well ?

4. Does 'instruction precede development' (L. S. Vygotsky)? Is learning to take place mechanically or from page to page within the textbook? Or, is it possible to save children from subsequent teaching, once the initial learning has been fully acquired? Quoting J. S. Bruner: "Is it possible to get a maximum of travel of what we have learnt?" If so, what kinds of thinking processes does training generate under different conditions? Are they the same as the preceding ones or are they different? Are they of temporary or of permanent character?
5. What errors do the children exhibit at various age levels? Are they, psychologically speaking, interpretable? Is it possible to develop a museum of these errors? Is it possible to demolish this museum through intervention? What is the role of maturity in this connection?
6. Is learning possible in the absence of schemes of thought in relation to academic subjects taught at school? Do these schemes of thought have any psychological existence or relevance?
7. Why do the children fail to verbalize their concepts or methods of procedure, especially when they have, in fact, acquired them?
8. Lastly, how do the children coordinate information? What are the underlying mechanisms? Have they strong links with symbolic logic? Are they of any psychological significance as well (4)?

Analysis of Adolescent Thought

The writer investigated adolescent thought with the help of specially designed problems (N=17), each inhering a continuous chain of reasoning (5). This study, using the case study approach, also attempted to delineate the structure of the various hypothesized schemes of thought factorially. In

this field experiment, 200 pupils (100 boys and an equal number of girls) studying in Grades VI through X matched on intelligence and socio-economic status were observed, solving a series of seventeen different problems in two sessions. The main findings of this study indicated that :

1. Except occasional fluctuations, average performance on each problem increases with grade. Mean performance in most of the cases favours boys rather than girls. But both boys and girls try hard to equalize their performance as they move into higher grades.
2. A given problem, or a part of the problem, or a process in that problem, is solved successfully (or failed) over a wide I. Q. range both within and across the various grades.
3. A given problem is solved in stages. It is possible to identify stages in the solution of any problem.
4. Unexpectedly, pupils commit a large number of errors while engaged in problem-solving. These errors further increase in the higher age-groups when they fail to grasp the main requirement of the problem. Among these errors, the dominant ones, shared by more than 15% of the pupils, largely speaking, suffer "a hump" before they finally decline with increasing grade.
5. Contrary to Piaget, pupils are not in a position to exhaust or suggest all possibilities, combinations and tests. Over three-fifths of the pupils from Grades VI to VIII are badly affected when a problem inheres reversibility in thinking.
6. The complex problem-solving processes arise from simple thinking processes,
7. The role of the nature of the problem being critical in investigating thinking, adolescent pupils, contrary to Piaget, are affected to a great extent by the content of the problem.

8. Although the adolescent pupils are in a position to set up hypotheses they are not in a position, contrary to Piaget, to test them, which shows that their minds have not yet become experimental. Most of the adolescent pupils do not, contrary to Piaget, possess schemes of proportion as well as generalization to algebraic symbols.

9 When a problem is solvable through two schemes of thought, one inferior and the other superior, and if the latter is not well developed, the resort to the former may favour quite a few in solving that problem. In case both are conspicuous by their absence, there is little chance for the supplied hint or illustration or even analogy to be utilized in solving the problem successfully

10. Except occasional fluctuations, the mean performance on the various schemes of thought shows an increasing trend with grade. When mean and standard deviation are kept at 20 and 3 respectively, the gains in terms of T scores over the five-year period are dismal, implying thereby that they are slow and laborious as they evolve across the grades.

11. Using Principal Component Analysis on the combined matrix, containing forty-five variables and the varimax rotated factor structures with a view to obtaining the hypothesized factors and interpreting them psychologically, the following multiple factors appeared :

    (a) Schematic Learning General
    (b) Adjustment
    (c) Problem Orientation
    (d) Sensing Problems
    (e) Symbolization
    (f) Testing Hypotheses
    (g) Using Constant Difference

(b) Aspect Character

(i) Seeing the Problem as a Whole

12. The top group differed from the bottom group on all the five measures of adjustment, understanding of the problem and all the seventeen schemes of thought. They, on the other hand, did not differ significantly from each other in respect of the following variables : felt difficulty of the problem and interest in the problem.

At this stage, it is necessary to highlight an interesting finding, hardly looked for, in this investigation. It has appeared in several contexts : supplying an answer already available within the body of the problem, last item requiring an arithmetical or algebraic answer; counting the total number of trials or efforts made; returning to the same step after suggesting other steps; and the number of arbitrary and extraneous considerations brought into the problematic situation during problem-solving. Why should these errors suffer a "hump" in the face of increasing understanding with age ? Is it the case of a lack of seriousness on the part of the adolescent ? Is it the case of adolescent being caught between the horns of a dilemma and getting murk ? Is it the case of the adolescent trying hard to close in on the problem very slowly through steps totally irrelevant to its solution ? Does it exemplify, suggesting in the process, that mastery over a thought process is through a path : uphill, thorny and often erratic ? Or, does the adolescent regress as if on an adventurous Piagetian journey during which, unaware of the logic he is using, he is trying hard to educate himself, thinking that the right path to concept development lies in flourishing an experimental failure ? Or alternatively, is it a case of rubbing his schemes of thought wrongly, especially

when he has personal reservations about his self-acquired knowledge in contrast to school learning which does not set right his firmly held self-centred thoughts ? It is anybody's guess. In a personal communication, J. S. Bruner, who had encountered this phenomenon earlier and had not followed it up, had this much to say :

The type of error that you refer to, which we speak of as growth error, is one in which the growing child tries out a new strategy although it is not well developed and uses it in place of an older one which has been working well. It is errors of this sort which suggest to me the venturesomeness of learning during this early period, that human beings are willing to shift to a less certain and more powerful strategy before they have it under control in perference to one which is safe, sound and dull (5).

Only a longitudinal study, however, is going to establish this Brunerian hypothesis. Returning to the "hump" effect, in serial rote learning, it appeared in the form of a 'bow' when frequencies of errors were plotted for a group of subjects engaged in learning, each item in the Serial Position Effect. In the present context, the problem arises : Does the 'hump' effect exist at the lower stages of mental development as well ? If so (and it is confirmed), a short tunnel to learning may be obtained, which may be theorized upon like the theory of fermentation. If effort in this direction is successful, the required fillip may usher in the second psychological revolution in learning consistent with the spirit of educational technology, especially when the second scientific and industrial revolution is picking up very fast in our country.

The investigation of human thought processes in all their varied aspects is a complex task, so both problems and acts

of problem-solving are bound to appear refractory both to the psychologists and the method specialists. Their troubles are bound to increase still further even when there is no unanimity in the published reports on the very definitions of thinking, concept-formation and problem-solving. Also how an experimental situation is to be finally selected and approached has not been discussed in detail in the literature in this field. But these difficulties, present to a varying extent in all research works, should not discourage the further investigator. Over two thousand years ago, Plato talked of breaking the problem at its joints. And it is aptly put forward by Hyde, the opportunity for that has just arrived.

There is scope for all : the clinical psychologist can study the abnormal functioning of the structure; the educationist can probe into the effects of training on mental growth; the sociologist can investigate into the effects of environment on individual differences. The value of knowledge that may eventually result from his work, directly or indirectly, is incalculable (6).

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